

**Technical Report 11-001**

## **Economic Development and Network Science**

**Margaret Moten, Daniel Evans**

U.S. Military Academy, West Point NY

**April 2011**

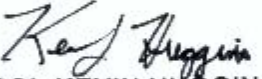


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## Economic Development and Network Science

### Limitations of Traditional Economic Theory

Much research has recognized that well-functioning financial markets are associated with economic growth. Levine and Zevros (1996) found that developed capital markets are correlated with improved economic performance, and there is a link between the size and liquidity of stock markets and easy access to information, rigorous accounting standards, and strong investor protections.<sup>1</sup> However, modern economic theory is failing both practitioners and policy-makers as the catastrophic financial crisis of 2007 – 2008 illustrates. The complex, interconnected economic and financial systems that exist today can only be understood in a network context.

Many of the basic assumptions underlying macro-economic and financial theory are so simplistic that the models upon which they are built cannot be used to predict or explain economic events. The concept of homo economicus assumes that individuals make rational decisions based on complete knowledge motivated by their self-interest in an effort to achieve the greatest benefit at the least cost. Simplifications inherent in the representative agent approach assume away complexities associated with the interconnectedness of economic actors and the effects of their actions on one another. The rational expectations theory, one of the cornerstones of financial economic theory, posits that individuals incorporate all available information when developing expectations and that prices today are a function of the individual's expectations about the future. Built upon the rational expectations theory, Fama's efficient markets hypothesis asserts that a security's price reflects all the available company and market information that is available.<sup>2</sup> Economic theorists, including John Maynard Keynes, have argued that perfect information and the rational man are idyllic concepts. Increasingly, their real-world applicability is being debated. The collapse of the financial system in 2007 highlights the shortcomings of the representative agent approach and

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<sup>1</sup> Levine, Ross and Sara Zervos (1996), "Stock Market Development and Long Run Growth," *World Bank Economic Review*, Vol. 10, No. 2.

<sup>2</sup> Fama, Eugene, "Efficient Capital Markets: A Review of Theory and Empirical Work," *Journal of Finance*, May 1970.

the dangers of failing to incorporate financial networks and their affects on risk and contagion. Economic research focused on modeling the behavior of networked, diverse economic agents is required to address these critical problems with economic theoretical foundations.

Kirman (2010) argues that individuals don't behave according to microeconomic principles and aggregation is a problem. "The homo economicus is not an accurate or adequate description of human decision making." He further questions assumptions such as representative agent, stability and uniqueness of equilibria, individual rationality, information availability, and an anonymous market. The recent financial crisis offers a bleak illustration. Financial institutions acting individually to maximize their returns and minimize risk spread increasingly complex financial instruments (that were not understood) throughout the financial system thereby destabilizing it. The highly interdependent network of financial institutions that evolved was not predicted or explained by economic models, resulting in the near collapse of the entire system. Kirman suggests that macroeconomic theory needs to incorporate the network of interacting individuals, the structure of their interactions, and the consequences of network activity.<sup>3</sup>

Stiglitz and Gallegati (2011) introduced new heterogeneous agent models to enhance our understanding of macro-economic behavior. Their model incorporates credit markets, credit linkages, and risks of bankruptcy because an increase in credit defaults leads to higher interest rates which increases the risk of additional borrower defaults and financial institution collapse. "In the real world, idiosyncratic shocks can well give rise to aggregative consequences; such shocks can be the source of an 'epidemic,' giving rise to financial distress, the effects of which diffuse throughout the economy, and can often translate into a contraction of real GDP. In other words, in a financial network idiosyncratic shocks usually do not cancel out in the aggregate,

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<sup>3</sup> Kirman, Alan. "The Economic Crisis is a Crisis for Economic Theory," CESifo Economic Studies, Vol. 56, 4/2010, 498 – 535, Oxford, Oxford University Press.

especially if a shock hits crucial nodes (hubs) of the network.”<sup>4</sup> For example, the bankruptcy of a major firm can induce a shock to both suppliers and creditors. If the firm and its suppliers represent a large enough portion of a bank’s lending portfolio, the bank’s solvency may be in jeopardy. The bank’s financial distress will limit its ability to lend to other borrowers causing them to either lose access to credit lines or increase their borrowing costs. This scenario illustrates why “... the structure of the network affects the aggregate impacts – [and] should be a prime focus of macroeconomic analysis.”<sup>5</sup>

The majority of the previous study involving network analysis and economics has focused on micro-economic theory with a general emphasis on decision-making, individual behavior, and game theory. Network scientists have delved into such topics as viral marketing and the economics of network-valued commodities, but increasingly researchers are recognizing the need to incorporate a network approach to enhance our understanding of macro markets. Individuals make economic decisions in a market context that is influenced by their social interactions and opportunities. Understanding the structure, dynamics, and unique characteristics of the capital market network in which they operate is vital to developing a better understanding of how capital markets evolve.

Economic analysis and prediction is further complicated in developing economies where individuals make reciprocal exchanges and clan or family interests are as important, or maybe more important than individual self-interest. Other important considerations are the social norms, institutions and legal frameworks within which individuals operate. Furthermore, information asymmetry and insufficient contract enforcement can limit the willingness of creditors and investors to provide critical investment funds. We expect our network approach to discover existing qualities of market behavior that do not adhere to traditional economic assumptions. This research is important not only because of the insight it gives to the study of network science, but

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<sup>4</sup> Stiglitz, Joseph E. and Mauro Gallegati, “Heterogeneous Interacting Agent Models for Understanding Monetary Economics,” *Eastern Economic Journal*, Volume 37, Winter 2011, pp. 6-12, Bloomsburg, PA, Eastern Economic Association.

<sup>5</sup> Ibid.

also because of the insight it provides about economics and capital markets. Network analysis can broaden our understanding of the critical factors affecting market development.

## **Capital Markets and Economic Development**

Based on research in African financial markets, Ndikumana (2001) found that market structure evolves to fit the country's income level.<sup>6</sup> In undeveloped economies, buyers and sellers exchange goods and services in barter transactions. As economies develop, banks often become the primary institutions that allocate funds from depositors to businesses and individuals with credit-worthy projects. As businesses mature and seek to expand, demand for capital fuels the development of capital markets to efficiently allocate savings to investment. Financial intermediaries help to identify the optimal investment options, improve information asymmetries, and monitor corporate management behavior.<sup>7</sup>

Well-functioning capital markets are an extremely important component of capitalism. "... At any given level of savings, an efficient financial system will allow for a higher level of investment by maximizing the proportion of savings that actually finances investment (Pagano 1993)." <sup>8</sup> Companies require funds to expand operations, develop new products and services, and construct facilities. Governments use capital market funding to develop and enhance infrastructure, for other government projects and initiatives, and to finance deficits. The ability to buy and sell stocks or bonds "on demand" at a reasonable price is a key criterion for a liquid capital market. Liquid markets have many buyers and sellers, relatively small spreads between buying and selling prices, and robust trading volumes. Few foreign investors are willing to participate in a frontier or emerging capital market unless they know they can sell their shares easily in markets that are well regulated. Investors require transparency – reliable information about a firm's financial condition, profitability, forecasts, share

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<sup>6</sup> Ndikumana, Leonce (2001). "Financial Markets and Economic Development in Africa," PERI Working Paper 17, Political Economy Research Institute, Amherst: University of Massachusetts.

<sup>7</sup> Ndikumana (2001), p. 26.

<sup>8</sup> Pagano, Marco (1993), "Financial Markets and Growth," *European Economic Review* 37, pp. 613 – 622.

prices, and management. Government stability, economic policies, taxation, and the ability to repatriate capital influence an investor's perception of the political risk of an investment and consequently the risk premium required. Offeral (1996) concludes that consistent and sustainable policies that promote growth, savings, and structural reforms such as reducing public sector dominance and deficits and developing efficient financial intermediation encourage private investment and economic recovery.<sup>9</sup>

A recent study of U.S. development efforts notes, "... in many ways, in fact, the United States has yet to develop a coherent or effective approach to economic development... The environment for such efforts is often a dizzying mosaic of organizations and countries plagued by misaligned – or even contrarily aligned – incentives, both among themselves and with the host nation."<sup>10</sup> Successful economic development requires that local entrepreneurs have access to the capital necessary for business development but little is understood about the types and functions of capital markets in the world's less-developed countries. These capital markets, often termed "frontier markets" are ones in which social connections play a much more critical role than in developed capital markets calling for a network approach to evaluating and classifying these markets. Network analysis can inform behavioral, financial and development economists seeking understand the essential characteristics that foster capital market development in countries where social capital can be as important as financial capital. As Stiglitz and Gallegati (2011) note, "Some network designs may be good at absorbing small shocks, when there can be systemic failure when confronted with a large enough shock. Similarly, some typologies may be more vulnerable to highly correlated shocks."<sup>11</sup> Goyal (2007) found that, "Network structure has significant effects on individual behavior and on social welfare." He concluded that some networks are better than others to promote socially desirable outcomes, and both the quality and

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<sup>9</sup> Offeral Erik (1996). "The Response of Investment and Growth to Adjustment Policies," *Finance & Development*, June, pp. 18 – 20.

<sup>10</sup> Patterson, Rebecca and Dane Stangler, "Building Expeditionary Economics: Understanding the Field and Setting Forth a Research Agenda," *Kauffman Foundation Research Series: Expeditionary Economics*, Kansas City, MO: Ewing Marion Kauffman Foundation, November 2010, p. 6.

<sup>11</sup> Stiglitz and Gallegati (2011), p. 9.

quantity of the links in the networks are important.<sup>12</sup> Understanding the personal, corporate, and information networks that underlie capital markets in developing economies is a critical component for developing programs that foster economic growth, expand economic opportunities, and mitigate risk.

### **Capital Market Networks**

Network analysis can provide tools for describing capital market structure and function. Capital markets offer a rich data collection environment as participants in capital markets, by design, seek to share information that most organizations tend to guard. Researchers are collecting extensive data about the individual actors in the network and using mathematical techniques to identify and evaluate the nodes in the network. Network science measures such as closeness, betweenness, and centrality provide insights into the various roles and groups in a network such as which nodes are the connectors, mavens, leaders, bridges, and isolates. Trust and information sharing are vital for capital markets to operate effectively. Capital market network typologies reveal how actors in the network are connected and highlight which individuals and organizations serve as central hubs and power brokers – connecting other individuals and sharing information in the network. Network analysis also identifies potential points of failure and which individuals and organizations are on the shortest paths between nodes and exhibit the most influence on other nodes. Conversely, network analysis reveals which individuals or organizations are on the periphery of the network, lacking information or resources. These network typologies also enable researchers to classify, compare and contrast capital market networks. These models will offer insights to behavioral, financial and development economists seeking to understand the interconnections between economic actors and their affects on financial markets, risk, and economic conditions.

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<sup>12</sup> Goyal, Sanjeev (2007). Connections: An Introduction to the Economics of Networks, Princeton: Princeton University Press, pp. 54, 27.

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